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A STUDY OF RIVER MEANDERS ON THE MIDDLE ROUGE[1]

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Given a stream flowing on a flat surface of homogeneous material, will it meander? If so, will the meanders develop at once, or will they be formed only after considerable time has elapsed? The answer to these questions was actually encountered in a millpond which had silted up for many years till its floor was level. Then the dam broke causing the river to flow in a narrow channel through the deposits. It is hoped that the behavior of the stream under these conditions may shed some light on the general question of the origin of meanders.

The conception generally held is, that the stage in the lives of rivers when they meander in broad arcs is reached late, when they flow sluggishly, as swift streams are less easily turned aside than those which flow less impetuously.

This supposes a turning aside from a straight course due to irregularities or obstructions in the path of the stream. The breaking out of ditches into meanders is held to support this view. This view of the origin of meanders is the one stated by Geikie, Russell, Davis, Chamberlin and Salisbury, and other authorities. It is also held in some quarters that meandering is a direct result of loading of the stream and deposition of the sediment.[2]

This paper concerns itself with a discussion of an actual case of meander development and shows that meanders may develop in a swift stream, that they are not always the result of a long process; but may develop immediately, and that inequalities of bed or obstructions in the path of the stream are not necessary for their formation.

The river on which meander development was studied was the Middle Rouge, one of the three upper branches of the River Rouge, a stream emptying into the Detroit River, as shown on the accompanying map of the vicinity, designed to show the relation of the locality to the surrounding country.

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[1] This case of meandering was discovered when on a field trip with Professor M. S. W. Jefferson of the Ypsilanti State Normal.

[2] Griggs, *Bull. Am. Geog. Soc.*, Vol XXXVIII, pp. 168–76.

Some seventy-five years ago a dam was built across the Middle Rouge near Pikes Peak. Since that time the dam has been maintained continuously, except that it broke in 1895. It was, however, immediately repaired so that to all intents and purposes the water has been ponded up continuously for about three quarters of a century.

The floor of the pond is composed of silt of very uniform character. Deposited under water as it was, and attaining a thickness of several feet, it presented a material of exceptional character for the river to cut into when the water was withdrawn from the surface by the break in the dam. The uniform character of the deposit, so far as any illustration can show it, is shown in Fig. 3, taken about 600 ft. above the dam on the right-hand bank of the stream.

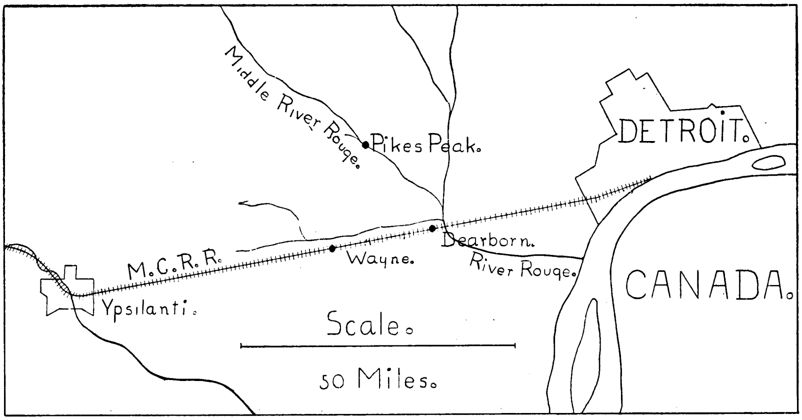

Fig. 1.—Map of the vicinity to show the relation of the locality to the surrounding country.

The deposit, which is a fine even clay with absolutely no bowlders or stones, has cracked extensively, and to considerable depths since the withdrawal of the water, and these cracks show plainly in the photograph. The vegetation (*Polygonum*) also shows; but as the picture was taken after snow had fallen, late in November, the luxuriance of its growth is not apparent.

The margins of the pond when first the dam was built, must have been the bluffs on either side of the flood plain and the pond must have extended back half a mile from the dam as is shown by the deposits. The pond when the dam broke, was much smaller, due to deposits of silt, its limits at the head of the valley being marked by the peculiar hummock or mound configuration built up by the sedge (*Carex stricta*) and added to later by turf-forming grasses.[1] These tuft formations mark off sharply the limits of the pond on the margins away from the dam and shown in Fig. 4. Here the stream has cut a narrow channel in the bed of the old, wider course, but preserved the old bed, the banks of the old course being marked off sharply, the

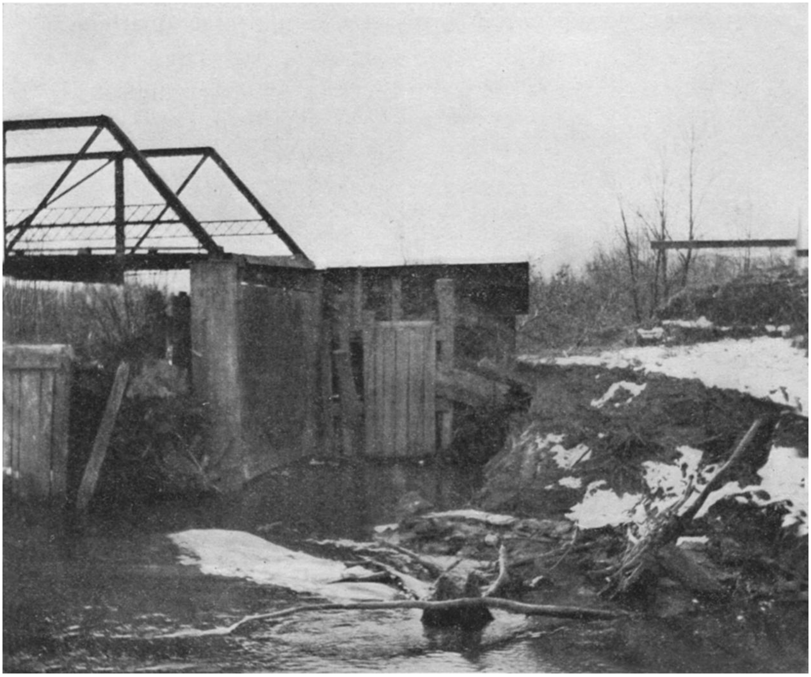

Fig. 2.—Break in Dam (looking S. E.). During high water on May 30, 1905, the dam gave way leaving a break at the end of the waste weir and bridge as shown in Fig. 2. When the water was drawn off, the floor of the pond was almost entirely covered with Knotweed (*Polygonum Muhlenbergii*) standing from three to five feet high.

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[1] Brown, *Bot. Gaz.*, October, 1905, p. 270.

hummock configuration showing on either shore, but better on the right.

The same is shown in the view of the entire valley (Fig. 5) in the foreground, where the present stream has inherited an old meander. This view down the river shows the bridge in the background and the bluffs on the left hand side of the valley. The wagon road also shows, and over to the left the houses at Pikes Peak may be seen. The character of the surface, with its tuft formations, the land reclaimed from the original pond by silting and subsequent additions by the growth of vegetation, also shows very well.

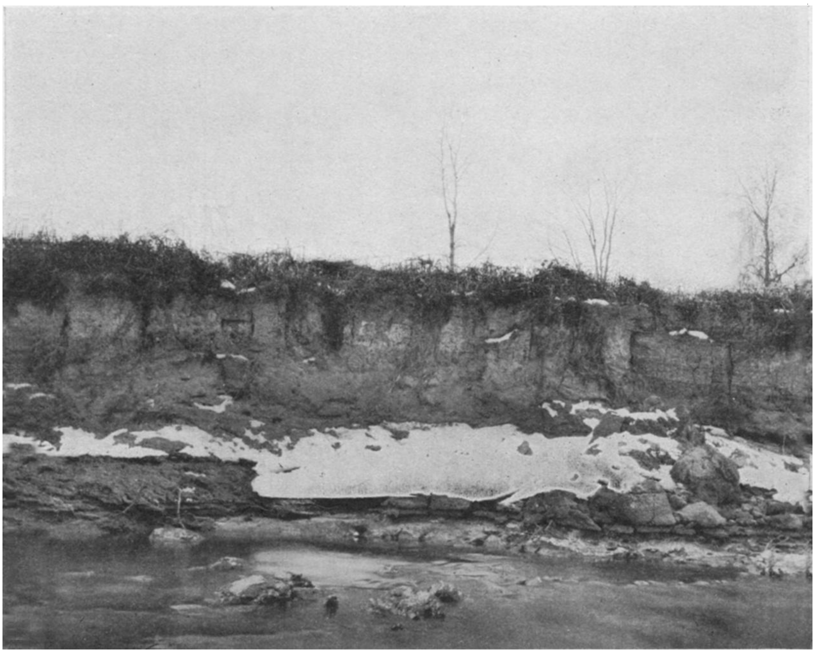

FIG. 3.—Section of silt where stream has cut seven feet into old pond floor.

The meander which shows is an inherited one, cut by the river in silt laid down in the original pond while the water was still ponded up, and deepened in a narrower channel since. The old banks show plainly on either side.

The bars on the inner side of the curves are of small extent and relatively steep slope, as the lateral cutting of the stream has as yet been very little. One of these bars shows in the foreground. They are in general composed of coarse material (sand and gravel), differing in composition from the banks of the stream.

The Rouge is so called from its color, which is owing to the sediment carried. The Middle Rouge, even though a small stream here, carries a great amount of sediment. A large portion of this was dropped in the pond while the dam was intact, the deposits reaching a depth of eight feet at the dam and extending back a distance of nearly half a mile.

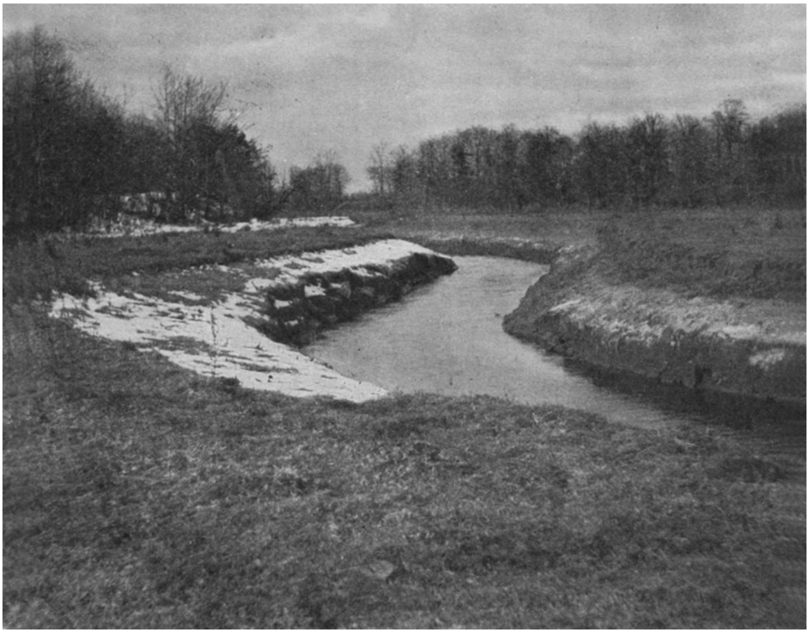

FIG. 4.—Present stream in an inherited wider bed.

The map accompanying the paper (Fig. 6) shows the meandering course of the stream in the old floor of the pond and extends back far enough to show all the meanders which have developed since the withdrawal of the water as well as one (the first of the series), which was developed earlier and has since simply been deepened.

The map has been constructed with considerable care, the principal points being located accurately, and the width of the stream measured carefully in many places.

At the present time, the river has cut through the old deposits and has regraded its floor so that the deposits stand out eight feet thick at the dam and thin out to nothing half a mile up stream.

Assuming that the floor of the pond is level, and it must be very nearly level when we consider that the top of the waste weir is only eleven feet above the bed of the stream and the silt reaches to within three feet of its top, we can see that when the dam gave way the river was flowing on a nearly level surface, certainly more nearly level than any other portion of the flood plain in the vicinity. It immediately began to cut into this deposit, however, and soon had a fall in half a mile of a trifle more than the thickness of the deposits, or something over ten feet.

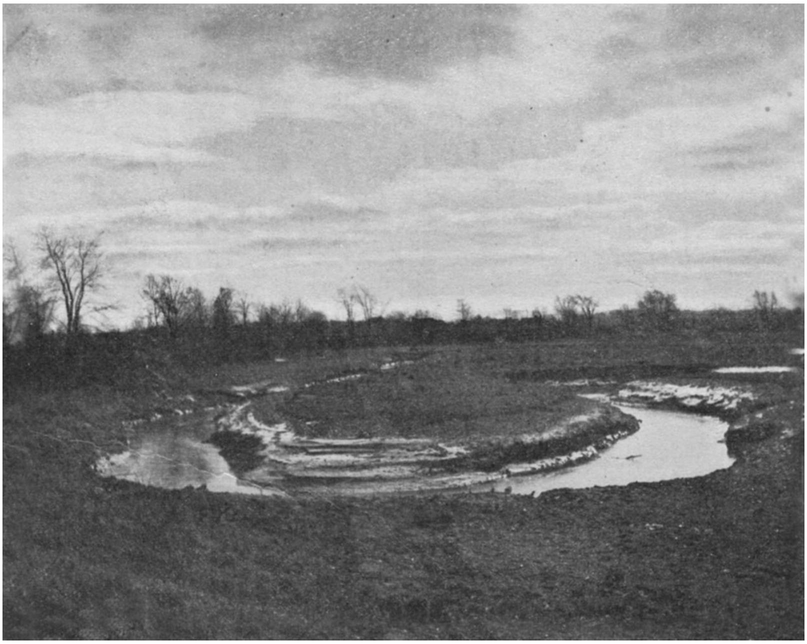

FIG. 5.—View down the river taken from bluffs at the head of the old mill pond.

To have been there and seen the events as they actually occurred would have been exceedingly interesting. Nothing could be learned

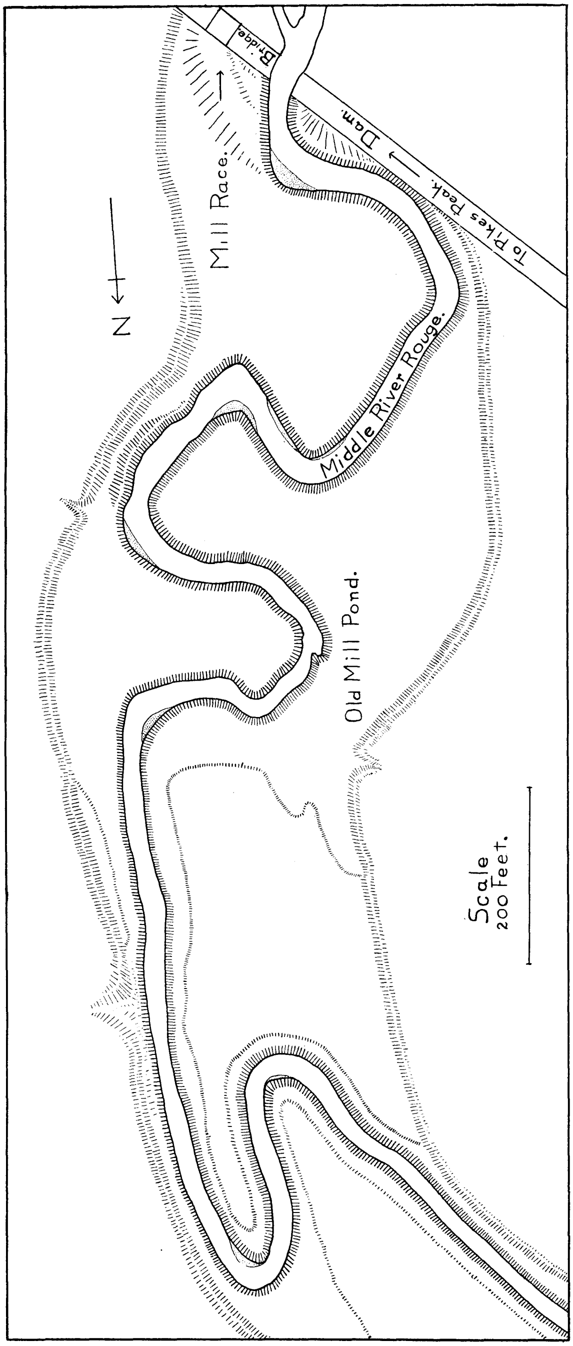

FIG. 6.—Map of the mill-pond at Pikes Peak.

in the vicinity, however, which seemed reliable enough to be taken as authority as regards the course of events, so it will be necessary to imagine what actually did occur from the final results.

The river, when first the dam broke, must have been free to flow on a practically flat surface, at least not uneven enough to cause it to swing from one side of the plain to the other. Neither can the character of the deposits have been the cause of the meandering which actually occurred. These meanders may or may not have been assumed practically as soon as the dam broke and deepened and made permanent since.

The meanders developed on the withdrawal of the water from the pond are not the old ones which the stream simply resumed with slight deviation. The old meanders were completely obliterated by silting. If this were not so, we should expect to find traces of old meanders which the present stream does not occupy, but which would be plainly visible as slight depressions in the valley floor. These we do not find in the floor of the old pond, though they occur both above and below in the valley floor. In fact, several "cut offs" have had time to form in the old deposits above water at the time the dam broke, farther up stream than shown on Fig. 6, but still in silt laid down in the original pond.

The old topography of the valley floor was not reproduced on the withdrawal of the water due to pressing out of the water entrapped in the subaqueous deposit by the increased gravity of the mass. It this were so, it would be peculiar that only one set of meanders should be produced and the stream should follow them. Others would show as well. The material deposited was a very fine, even clay and the amount of settling which it would undergo on the withdrawal of the water, from a shallow pond perhaps three or four feet deep would be problematical, and perhaps of more theoretical than practical importance in the determination of the course of a stream whose course was determined within a few hours after the break in the dam.

The silting up of the pond was certainly complete enough to obliterate entirely the old stream courses and the settling of the mass which would occur in 24 hours did not reproduce them. The new meanders are independent of the old.

The probability is, that while the water of the pond was draining off, the flat character of the bottom caused the water to flow in a thin broad stream, and that the meanders were caused or formed as the narrower stream cut back from the dam. This is rendered probable by the fact that near the dam, in so far as there are any inequalities of surface, the water does not occupy the lowest land. This would tend to show that inequality of surface was not the determining factor in causing the meandering. The question naturally arises: What did cause the stream to meander?

According to the U. S. contour map of the locality, the average fall of the stream per mile is about ten feet above the old pond and about six feet below. If the stream had assumed a straight path, it would have had a fall of over thirty feet to the mile in the floor of the old pond. As a matter of fact, it, by its meandering course, reduces the fall to about fifteen feet to the mile. These numbers are only approximations; but can be verified by consulting the accompanying map. Even this is more than the average fall per mile in the course of the stream. This is what we should expect, as while in the old pond the stream has graded its course, it is still cutting down to conform to the grade of the stream as a whole, which it will reach in time.

Considering the width of the flood plain, however, it will be seen that it would be impossible for the stream to decrease its rate of fall farther by meandering, as it already swings from side to side, cutting into both boundary bluffs. In so far as the conditions permit, the stream has apparently endeavored to conform to the general grade of its course in its path across the floor of the old pond. This gives rise to some very interesting questions.

What does meandering mean? Does it mean a response to surface configuration? Is it dependent upon the nature of the material in which the river is cutting its course? Does it bear any relation to stream velocity? Is it necessarily associated with the lower courses of streams because of a decrease in velocity, or is it because of a decrease in freedom to meander due to the width of the flood plain caused by lateral cutting?

These meanders are not inherited, neither are they the result of lateral cutting. Most of the work done by the river since the dam gave way has been vertical cutting. The banks are vertical and remain so on account of the fine, homogeneous clay of which they are composed. Only in an occasional place, and then only in small amount, has any lateral cutting whatever occurred.

What then does meandering mean? It would seem from this one case, that meandering is rather an expression of the river's attempt to establish a certain grade and fix a certain relation between its slope and the amount of sediment carried, that meandering is not dependent upon the character of the material and may proceed in deposits in which there are no obstructions to start meandering, that meanders are not always the result of a long process, but that a meandering course may be the one first chosen, and that a swift stream, when free to assume the path it chooses, will meander.

This is, of course, more in the nature of a suggestion than a definite statement as to the cause of meandering, as one case is not sufficient to establish the point, but it should be possible to find many other examples of character similar to this, and a careful study of such cases would certainly help us to a better understanding of the behavior of meandering streams.